Abstract

Over the last few years, the smart grid and renewable energy environment have attracted heightened interest and relevance from governments and investors for the purpose of decreasing their dependency on fossil fuels as a source of energy. Another objective it serves is to increase the reliability of the system by utilising smart technology and communication capabilities. Consequently, the dependency on the power converters and the communication systems continues to rise in order to link the grid elements with each other, thereby creating a complex environment. As such, one of the challenges resulting from this 'complex' environment is the Electromagnetic Compatibility (EMC) between the smart grid devices. The EMC is the ability of several devices to work simultaneously in the same environment without interfering with each other, however, this is not the case with the smart grid.

In most cases, the power converter's modulation is the main source of emissions in the smart grid. Thus, the focus of this thesis remains only on the conducted emissions in the low-frequency range. The EMC standards deal with managing the amplitude of the emissions generated from the devices at any given frequency range. A great many studies have been interested in the use of Spread-Spectrum modulation (SSM) as an Electromagnetic Interference (EMI) amplitude mitigation tool. Notably, the communication systems operating in the smart grid are the main victim, as most of the power converters switching modulation frequencies lay in the same frequency range as the communication systems.
Set in this context, this thesis aims to provide a full vision of the influence of the spread-spectrum modulated EMI on the PLC communication system. The SSM works to distribute the signal power by randomizing the modulation parameters. The PLC system works by the OFDM modulation, which works also by distributing the communication signal to several sub-carriers. Hence, the objective is to answer the following questions:

1. What will be the effect of the SSM parameters on the PLC performance?
2. What is the link between the SSM parameters and the PLC communication parameters?
3. What are the best SSM settings that could provide both the EMI mitigation and the communication robustness?
4. Is it possible to improve the reliability of the PLC data transmission by control algorithms and modulation parameters of power electronics converters operating in nearby electromagnetic environments?

To meet the research needs, a proposed testbed is implemented to couple both the power and the communication circuit. The performance of the communication system is analysed under several various operating scenarios using two approaches to assure the robustness of the results—(1) measuring the Frame Error Rate (FER) throughout the communication channel, and; (2) calculating the channel capacity of the used channel by the Shannon Hartley equation. Finally, a statistical analysis has been carried out to link the SSM settings with the behaviour of the PLC systems and distinguish the best criteria for designing the SSM control of the converter.

In conclusion, the purpose of the thesis is to assure the robustness of the power line communication data transmission capability by controlling the modulation parameters of power electronic converters working in nearby electromagnetic environment.